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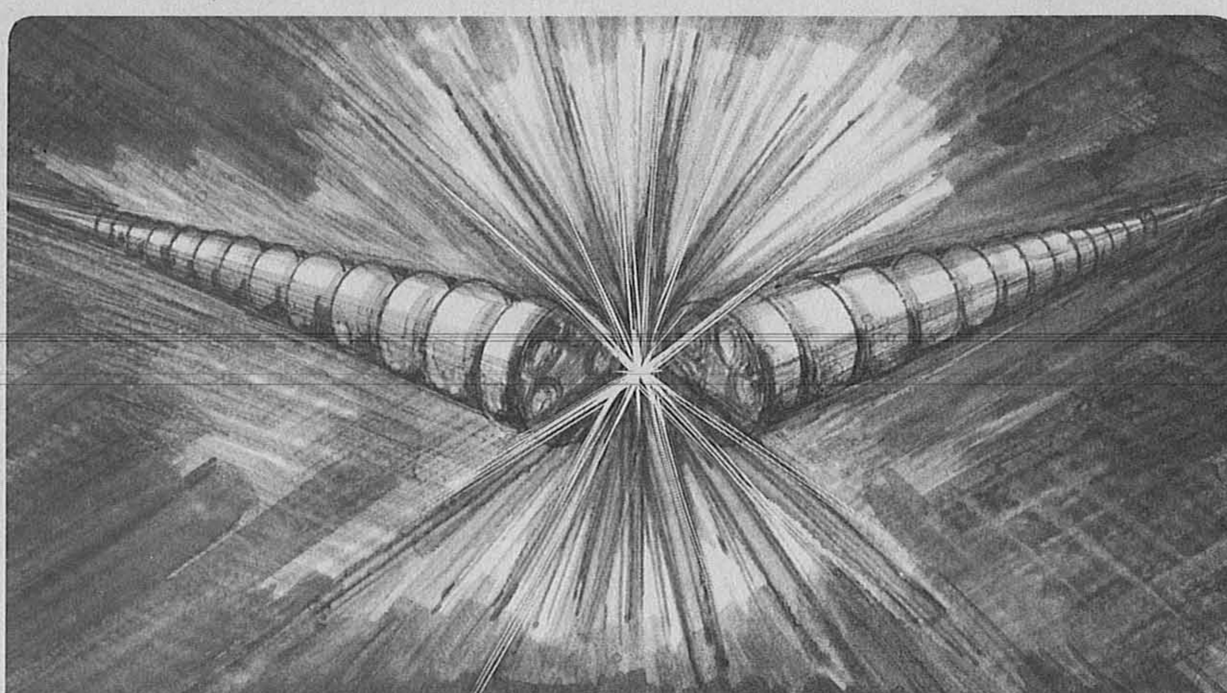

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COAXIAL WIRE IMPEDANCE MEASUREMENTS OF BPM BUTTONS FOR THE PEP-II B-FACTORY*

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Measurement technique

The coaxial wire impedance measurement uses a conducting rod placed along the beam axis in the vacuum chamber, forming the center conductor in a coaxial line system [1]. Tapers at either end of this section allow for smooth impedance transformation from the 50 Ω lines used in common microwave measurement equipment, to the characteristic impedance of the vacuum chamber and center conductor, typically around 200 Ω. RF and microwave absorptive material placed in the ends of the vacuum chamber and in the impedance matching tapers minimizes reflections which cause trapped modes within the apparatus, allowing measurements to be made above the traveling-wave cut-off frequency of the vacuum vessel (typically 2.5 - 3.0 GHz for PEP-II). A smooth vessel of the same cross-section as that containing the device under test is used in a reference measurement. Resonances within the apparatus are difficult to avoid completely and require careful placing of absorptive material, manufacture of test and reference chambers, and assembly of apparatus.

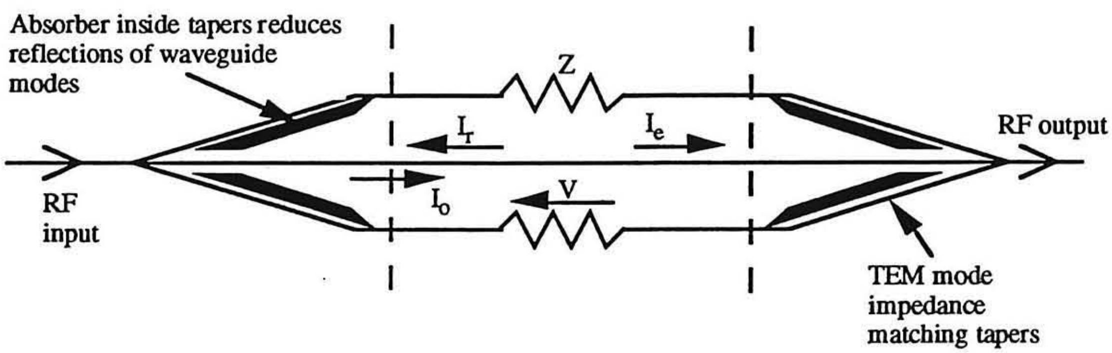

Figure 1. Coaxial wire impedance measurement.

Current I_o is applied upstream of the impedance to be determined, Z. The coaxial wire forms a line of characteristic impedance R with the vacuum chamber. A voltage V is generated at the impedance, inducing currents V/2R traveling equally upstream and downstream. For a localized impedance (small in extent compared to the wavelength of the applied current), the current that excites the voltage V in the impedance is $I_e = I_o - I_r$. The perturbation in wire current $\Delta I = I_o - I_e = V/2R = I_e Z/2R$, and $Z = 2R(I_o - I_e)/I_e$, $= 2R(I_o/I_e - 1)$. S_{21} measurements without the impedance Z (reference measurement) and with the impedance Z (object measurement) give

$$Z = 2\,R\left(\frac{S_{21}^{\text{reference}}}{S_{21}^{\text{object}}} - 1\right)$$

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BPM button measurements

BPM button measurements were made with a single button mounted in a short section of vacuum chamber of appropriate cross-section (elliptical for the LER, octagonal for the HER, and circular for the straights of both rings). For a reference measurement, the button assembly was replaced with a tightly fitting solid metal plug, flush with the vacuum chamber inner wall. The first BPM design was for a 2 cm diameter button, which showed a TE_{11} resonance, located at the button circumference, at approximately 6 GHz. Figure 2 shows the real part of the impedance in this region. Since we have approximately 1160 buttons in each ring, the contribution to the total impedance from the buttons is not negligible [2]. The resonance may be suppressed by cutting a flat across the button, breaking the symmetry of the structure, figure 3 shows the measured impedance in this case [2].

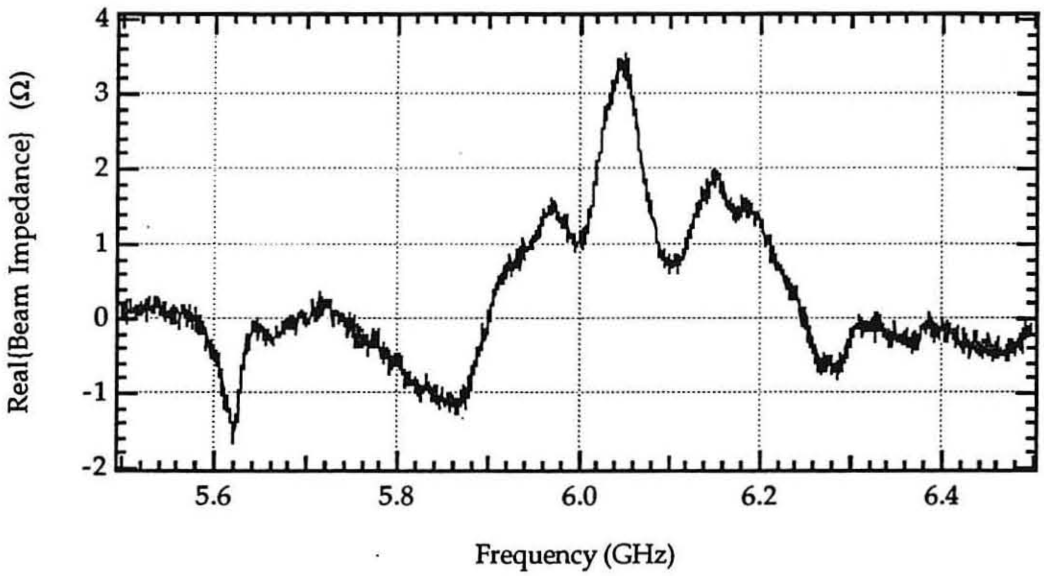

Figure 2. TE_{11} mode in 2.0 cm circular BPM button, straight vacuum chamber.

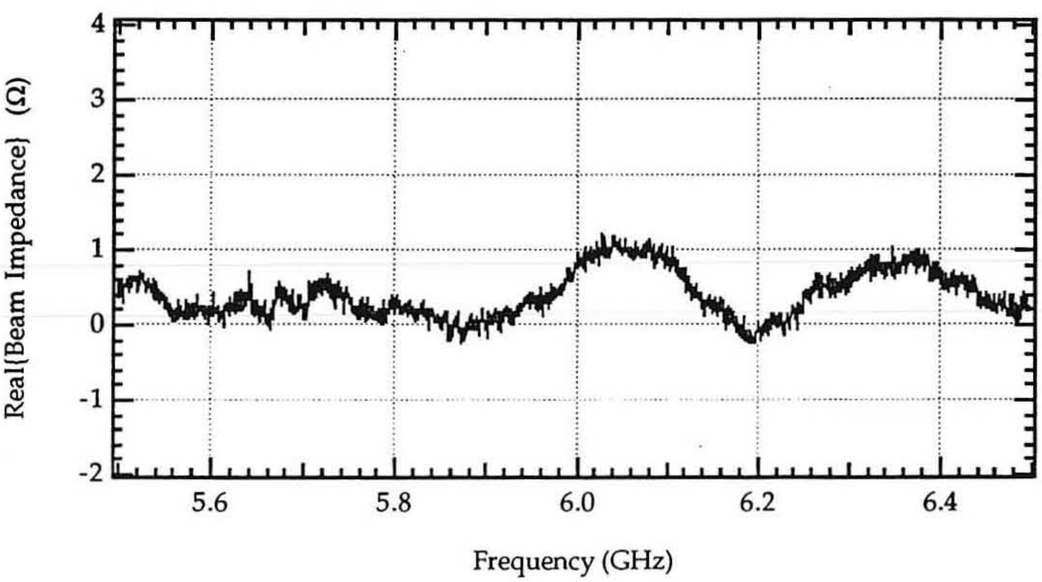

Figure 3. TE_{11} mode suppressed with flat cut 6 mm from the edge of a 2 cm BPM button .

In order to simplify manufacture and installation and to minimize costs, the final design uses a 1.5 cm diameter circular button. The TE_{11} resonance is still present, but at 7.7 GHz, and the effective impedance of this mode is reduced as a result of the roll-off of the single-bunch spectrum. Coupled bunch motion driven by this impedance is well within the capabilities of the feedback systems. Figure 4 shows the measured beam impedance of the 1.5 cm button. The measurements are qualitatively in good agreement with computations, but with a lower impedance than predicted by MAFIA, likely due to the finite conductivity of the real button and feedthrough assembly [3].

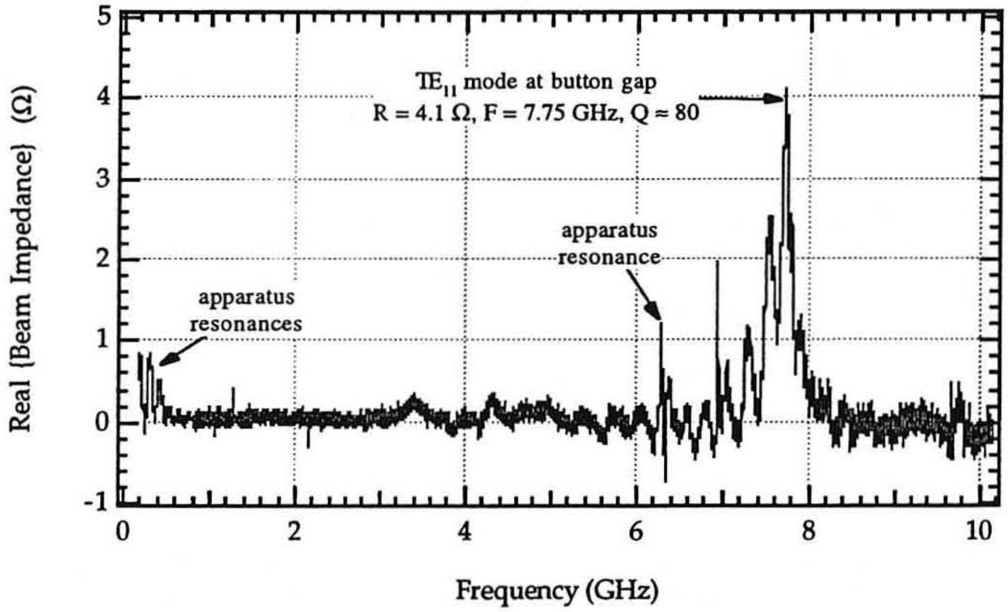

Figure 4. 1.5 cm BPM button in HER arc chamber.

The transfer impedance measurement uses the coaxial wire and takes the output signal from the button in an S_{21} measurement. The impedance is given by

$$|Z_{transfer}| = \sqrt{R\,R_{button}}\left|\frac{S_{21}^{pickup}}{S_{21}^{through}}\right|$$

where R_{button} is the output impedance of the button (50 Ω), $S_{21}{}^{pickup}$ is the transmission from the vacuum chamber coaxial line to the button output, and $S_{21}{}^{through}$ is the transmission through the vacuum chamber line. Figure 5 shows the transfer impedance for the 1.5 cm button, which is in good agreement with MAFIA computations [3].

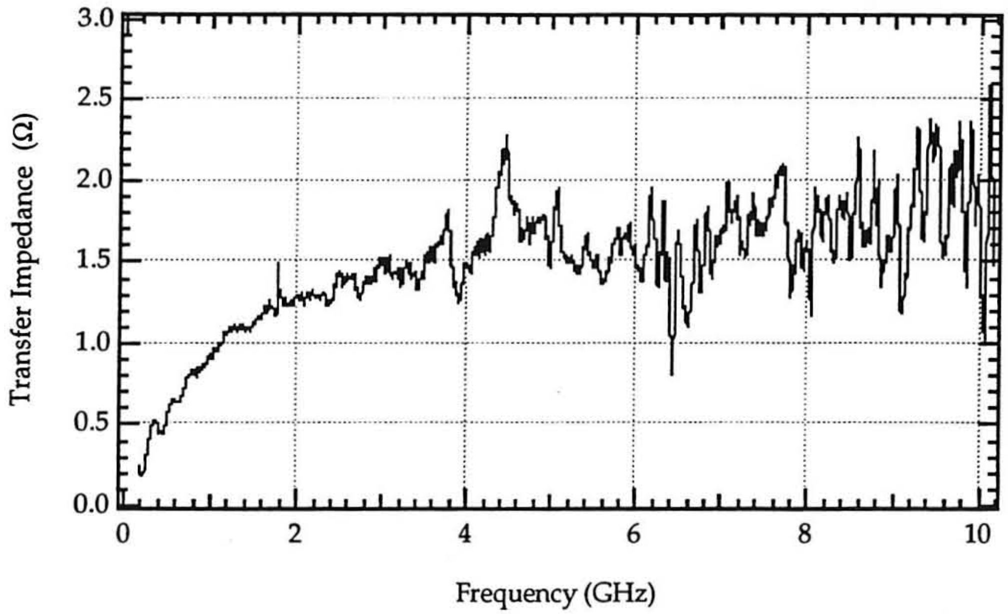

Figure 5. 1.5 cm BPM button in HER arc chamber.

References

[1] F. Caspers, "Beam Impedance Measurements using the Coaxial Wire Method", Proc. Workshop on Impedance and Current Limitations, ESRF, Grenoble, October 17-18, 1988.

[2] N. Kurita, D. Martin, C.-K. Ng, S. Smith, and T.Weiland, "Simulation of PEP-II Beam Position Monitors", PEP-II Technical Note No. 87, March 1995. See also these proceedings.

[3] C. Ng, private communication. See also these proceedings.

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